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(54) **DISPLAY DEVICE AND METHOD OF DRIVING THE SAME**

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(52) **U.S. Cl.**
CPC ***G09G 3/20*** (2013.01); *G09G 2320/04* (2013.01); *G09G 2340/045* (2013.01); *G09G 2340/0414* (2013.01); *G09G 2340/0421* (2013.01); *G09G 2380/02* (2013.01)

(58) **Field of Classification Search**
CPC G09G 3/20; G09G 2320/04; G09G 2340/0414; G09G 2340/0421; G09G 2340/045; G09G 2380/02
See application file for complete search history.

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(57) **ABSTRACT**

A display device including a display panel including scan lines, data lines, and first pixels disposed thereon, an expansion detecting unit configured to determine expansion of the display panel, a control unit configured to generate a control signal to correct an image signal depending on a degree of expansion when the display panel is determined to be expanded, a scan driver connected to the scan lines and configured to apply the control signal to the scan lines connected to the corresponding pixels depending on the control signal input from the control unit, and a data driver connected to the data lines and configured to apply the control signal to the data lines connected to the corresponding pixels depending on the control signal input from the control unit.

20 Claims, 11 Drawing Sheets

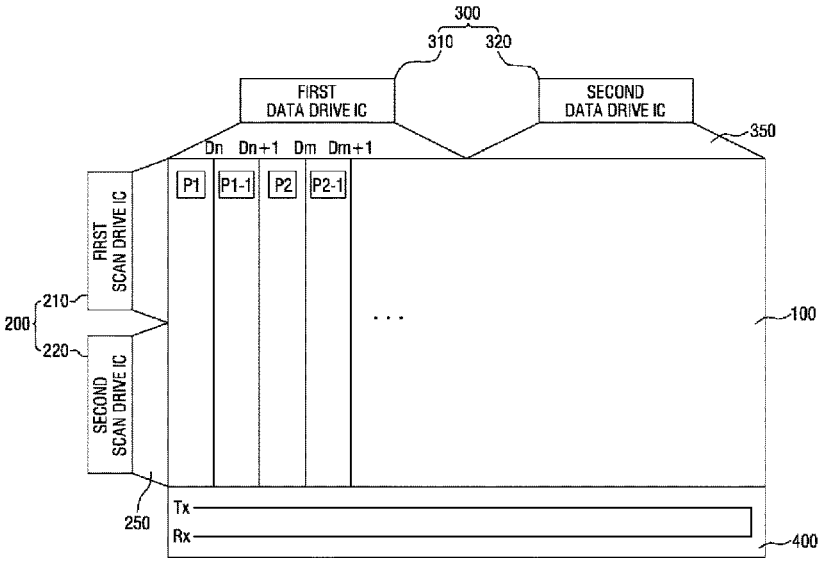

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FIG. 1

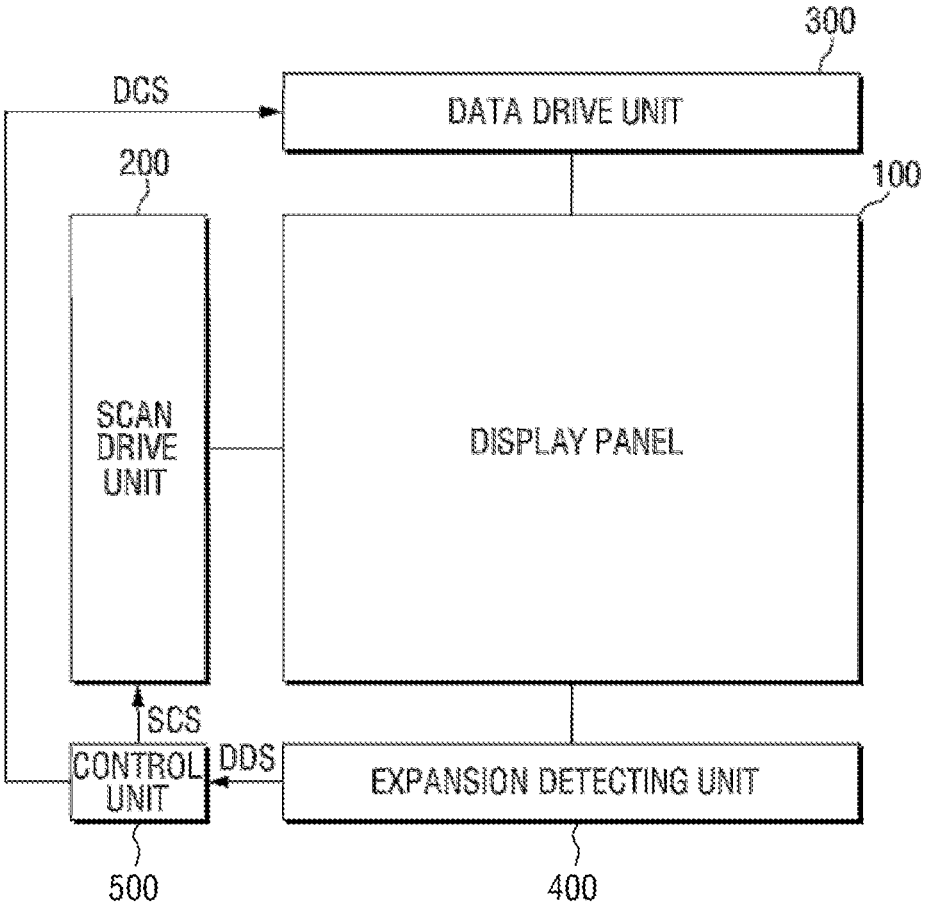

300
DCS
DATA DRIVE UNIT
200
100
SCAN DRIVE UNIT
DISPLAY PANEL
SCS
CONTROL UNIT
DDS
EXPANSION DETECTING UNIT
500
400

FIG. 2

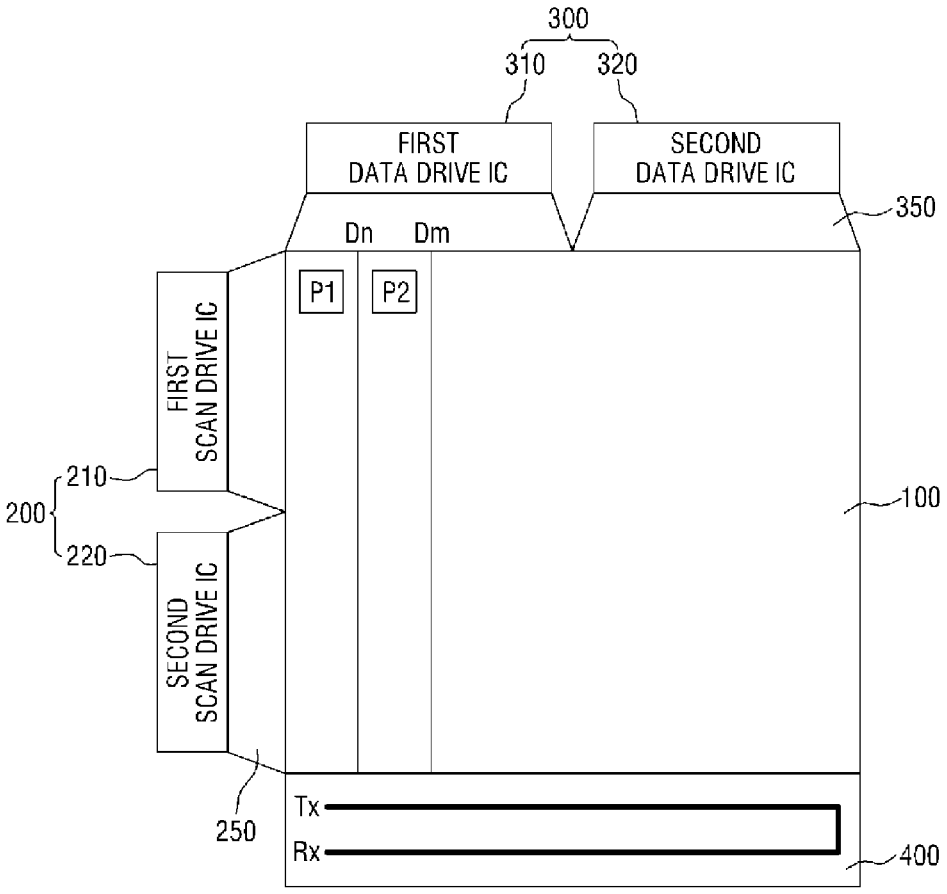

300
310
320
FIRST DATA DRIVE IC
SECOND DATA DRIVE IC
350
Dn
Dm
P1
P2
FIRST SCAN DRIVE IC
SECOND SCAN DRIVE IC
210
200
220
100
250
Tx
Rx
400

FIG. 3

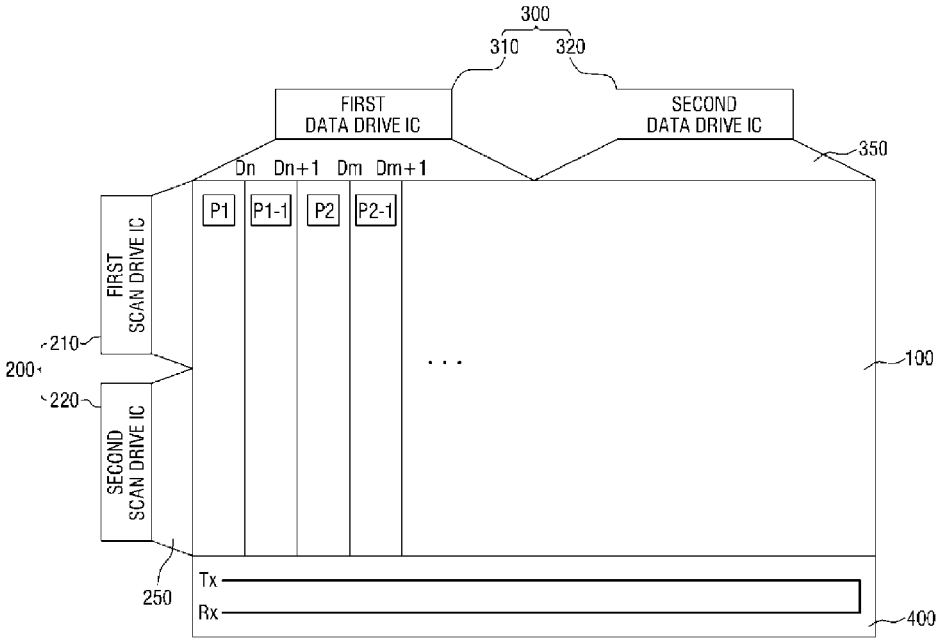

300
310
320
FIRST DATA DRIVE IC
SECOND DATA DRIVE IC
350
Dn
Dn+1
Dm
Dm+1
P1
P1-1
P2
P2-1
FIRST SCAN DRIVE IC
SECOND SCAN DRIVE IC
210
200
220
100
250
Tx
Rx
400

FIG. 4

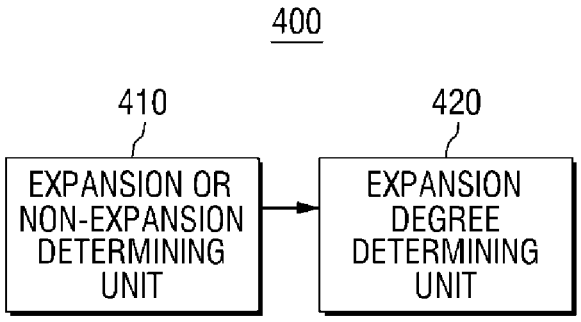

400
410
420
EXPANSION OR NON-EXPANSION DETERMINING UNIT
EXPANSION DEGREE DETERMINING UNIT

FIG. 5

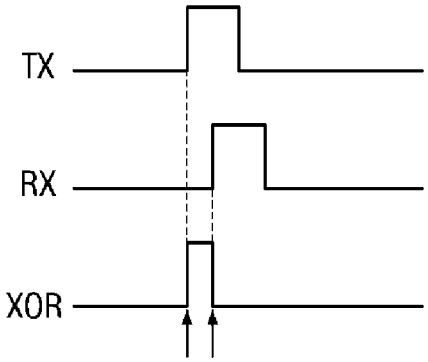


FIG. 6

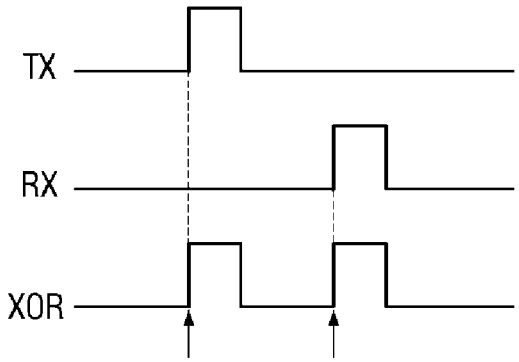


FIG. 7

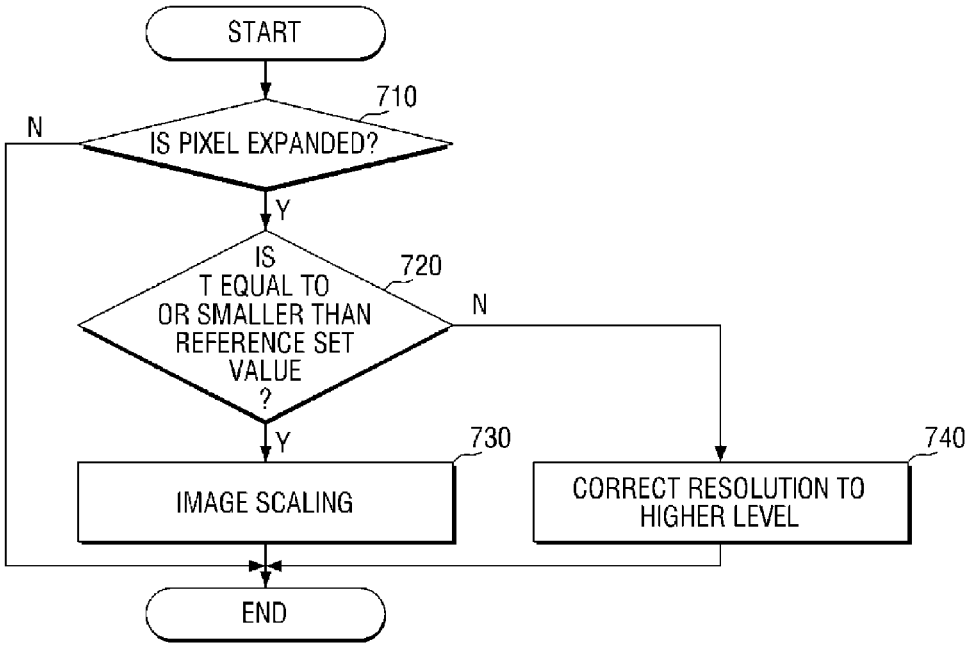

START
710
IS PIXEL EXPANDED?
N
Y
IS T EQUAL TO OR SMALLER THAN REFERENCE SET VALUE ?
720
N
Y
730
IMAGE SCALING
740
CORRECT RESOLUTION TO HIGHER LEVEL
END

FIG. 8

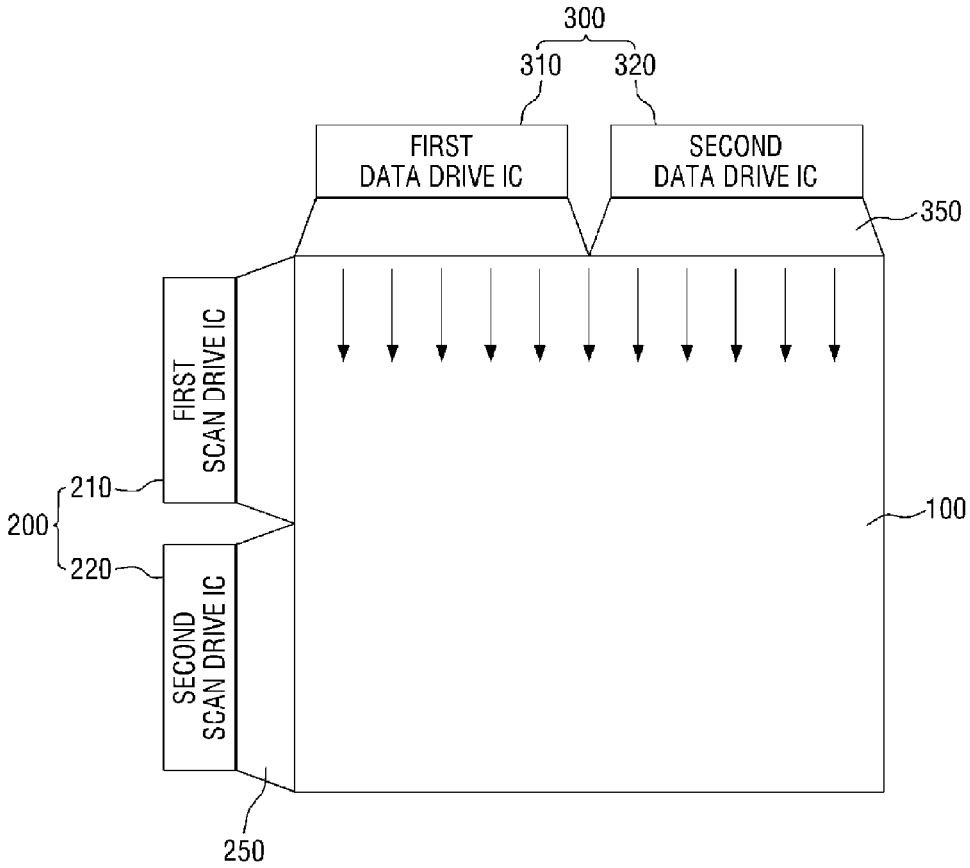

300
310
320
FIRST
DATA DRIVE IC
SECOND
DATA DRIVE IC
350
FIRST
SCAN DRIVE IC
210
200
220
SECOND
SCAN DRIVE IC
100
250

FIG. 9

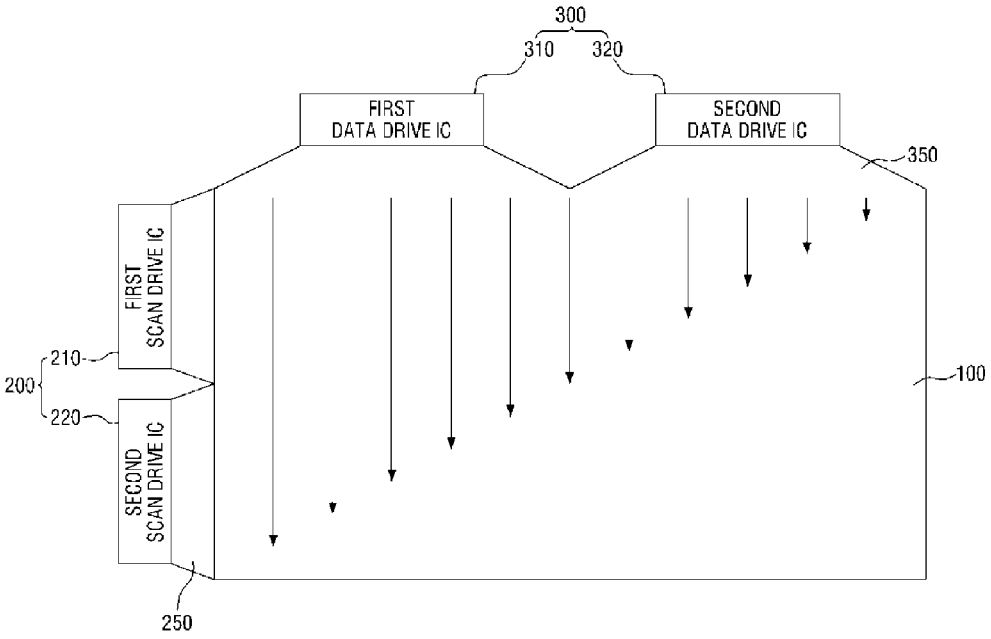

300
310
320
FIRST DATA DRIVE IC
SECOND DATA DRIVE IC
350
FIRST SCAN DRIVE IC
210
200
220
SECOND SCAN DRIVE IC
100
250

FIG. 10

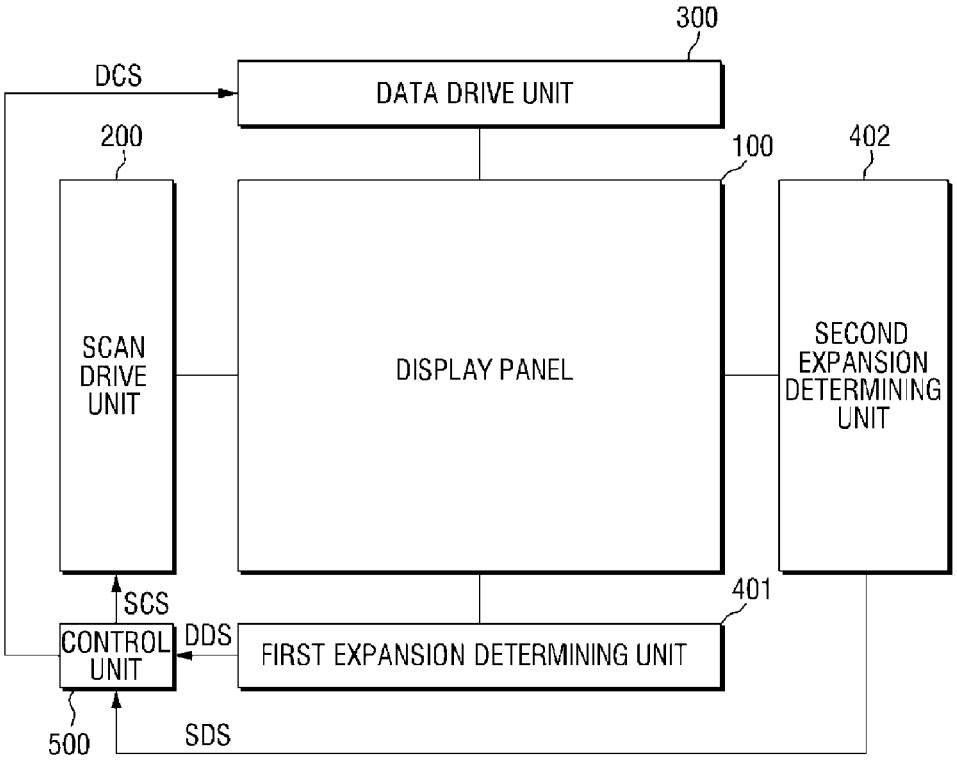
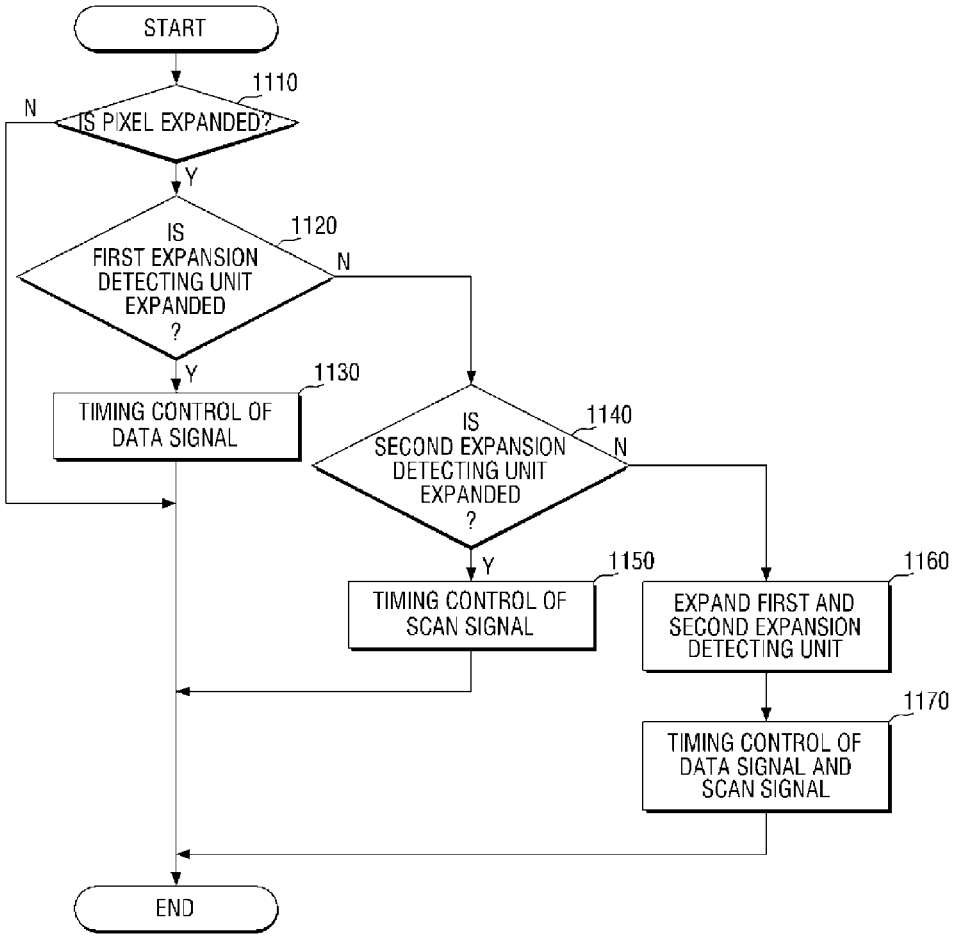

300
DCS
DATA DRIVE UNIT
200
100
402
SCAN DRIVE UNIT
DISPLAY PANEL
SECOND EXPANSION DETERMINING UNIT
401
SCS
CONTROL UNIT
DDS
FIRST EXPANSION DETERMINING UNIT
500
SDS

FIG. 11


START
1110
IS PIXEL EXPANDED?
N
Y
IS FIRST EXPANSION DETECTING UNIT EXPANDED ?
1120
N
Y
TIMING CONTROL OF DATA SIGNAL
1130
IS SECOND EXPANSION DETECTING UNIT EXPANDED ?
1140
N
Y
TIMING CONTROL OF SCAN SIGNAL
1150
EXPAND FIRST AND SECOND EXPANSION DETECTING UNIT
1160
TIMING CONTROL OF DATA SIGNAL AND SCAN SIGNAL
1170
END

DISPLAY DEVICE AND METHOD OF DRIVING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority from and the benefit of Korean Patent Application No. 10-2015-0001207, filed on Jan. 6, 2015, which is hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND

Field

Exemplary embodiments of the present invention relate to a display device, and more particularly, to a display device including a flexible material and a method of driving the same.

Discussion of the Background

Demand for small and light flat-panel display device has been increasing, as a flat-panel display device may be used in display devices such as, a TV, a PC, a laptop computer, a tablet PC, a mobile phone, and an MP3 player. A type of a flat-panel display device that meets user demands has been studied. A flexible display device may be bent or folded by users.

In some cases, a display panel of the flexible display device may be expanded by external force.

When the display panel is expanded, pixels of the display panel may also expand to distort the image displayed in the expanded area.

The above information disclosed in this Background section is only for enhancement of understanding of the background of the inventive concept, and, therefore, it may contain information that does not form the prior art that is already known in this country to a person ordinary skill in the art.

SUMMARY

Exemplary embodiments of the present invention provide a display device that may prevent the degradation of display quality in a flexible display device by detecting the degree of expansion of the display panel, to correct an image depending on the degree of expansion.

Exemplary embodiments of the present invention also provide a method of driving the display device that may prevent the degradation of display quality in a flexible display device by detecting the degree of expansion of the display panel, to correct an image depending on the degree of expansion.

Additional aspects will be set forth in the detailed description which follows, and, in part, will be apparent from the disclosure, or may be learned by practice of the inventive concept.

According to an exemplary embodiment of the present invention a display device includes a display panel including scan lines, data lines, and first pixels disposed thereon, an expansion detecting unit configured to determine expansion of the display panel, a control unit configured to generate a control signal to correct an image signal depending on a degree of expansion when the display panel is determined to be expanded, a scan drive unit connected to the scan lines and configured to apply the control signal to the scan lines connected to the corresponding pixels depending on the control signal input from the control unit, and a data drive unit connected to the data lines and configured to apply the control signal to the data lines connected to the corresponding pixels depending on the control signal input from the control unit.

According to an exemplary embodiment of the present invention, a display device includes a display panel including scan lines, data lines, and pixels disposed on the display panel in a region defined by the scan lines and the data lines, an expansion detecting unit configured to determine expansion of the display panel, a control unit configured to generate a control signal and control the operation of a scan drive unit and a data drive unit depending on a degree of expansion when the display panel is determined to be expanded, in which the scan drive unit is connected to the scan lines and configured to apply the control signal to the scan lines connected to the corresponding pixels depending on the control signal input from the control unit, the a data drive unit is connected to the data lines and configured to apply the control signal to the data lines connected to the corresponding pixels depending on the control signal input from the control unit, and the scan drive unit and the data drive unit are configured to control a timing of a scan signal or a data signal applied to the display panel depending on the degree of expansion of the display panel.

According to an exemplary embodiment of the present invention, a method of driving a display device includes determining whether the display panel is expanded by an external force, comparing a reference set value with a calculated value to determine a degree of expansion in response to determining the display panel is expanded, scaling an image signal when the reference set value is greater than the calculated value, and increasing a resolution of the image signal when the reference set value is smaller than the calculated value.

The foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the inventive concept, and are incorporated in and constitute a part of this specification, illustrate exemplary embodiments of the inventive concept, and, together with the description, serve to explain principles of the inventive concept.

FIG. **1** is a block diagram schematically illustrating a display device according to an exemplary embodiment of the present invention.

FIG. **2** is a plan view schematically illustrating a partial configuration before expansion of the display device of FIG. **1**.

FIG. **3** is a plan view schematically illustrating a partial configuration after expansion of the display device of FIG. **1**.

FIG. **4** is a block diagram schematically illustrating a configuration of an expansion detecting unit of FIG. **1**.

FIG. **5** is a timing diagram illustrating a change in signal level of the expansion detecting unit before expansion of the display device of FIG. **1**.

FIG. **6** is a timing diagram illustrating a change in signal level of the expansion detecting unit after expansion of the display device of FIG. **1**.

FIG. **7** is a flowchart illustrating a method of controlling the display device of FIG. **1**.

FIG. **8** is a plan view schematically illustrating application of signal to a display unit from a data drive unit before

expansion of the display device according to an exemplary embodiment of the present invention.

FIG. **9** is a plan view schematically illustrating application of signal to the display unit from the data drive unit after expansion of the display device according to an exemplary embodiment of the present invention.

FIG. **10** is a block diagram schematically illustrating a display device according to an exemplary embodiment of the present invention.

FIG. **11** is a flowchart illustrating a control method of the display device of FIG. **10**.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of various exemplary embodiments. It is apparent, however, that various exemplary embodiments may be practiced without these specific details or with one or more equivalent arrangements. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring various exemplary embodiments.

In the accompanying figures, the size and relative sizes of layers, films, panels, regions, etc., may be exaggerated for clarify and descriptive purposes. Also, like reference numerals denote like elements.

It will be understood that when an element or layer is referred to as being "on", "connected to", or "coupled to" another element or layer, it can be directly on, directly connected to, or directly coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly connected to", or "directly coupled to" another element or layer, there are no intervening elements or layers present. It will be understood that for the purposes of this disclosure, "at least one of X, Y, and Z" can be construed as X only, Y only, Z only, or any combination of two or more items X, Y, and Z (e.g., XYZ, XYY, YZ, ZZ). As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

Although the terms first, second, etc. may be used herein to describe various elements, components, regions, layers, and/or sections, these elements, components, regions, layers, and/or sections should not be limited by these terms. These terms are used to distinguish one element, component, region, layer, and/or section from another element, component, region, layer, and/or section. Thus, a first element, component, region, layer, and/or section discussed below could be termed a second element, component, region, layer, and/or section without departing from the teachings of the present disclosure.

Spatially relative terms, such as "beneath," "below," "lower," "above," "upper," and the like, may be used herein for descriptive purposes, and, thereby, to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the drawings. Spatially relative terms are intended to encompass different orientations of an apparatus in use, operation, and/or manufacture in addition to the orientation depicted in the drawings. For example, if the apparatus in the drawings is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the exemplary term "below" can encompass both an orientation of above and below. Furthermore, the apparatus may be otherwise oriented (e.g., rotated 90 degrees or at other orientations), and, as such, the spatially relative descriptors used herein interpreted accordingly.

The terminology used herein is for the purpose of describing particular embodiments and is not intended to be limiting. As used herein, the singular forms, "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. Moreover, the terms "comprises," "comprising," "includes," and/or "including," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, components, and/or groups thereof, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure is a part. Terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense, unless expressly so defined herein.

FIG. **1** is a block diagram schematically illustrating a display device according to an exemplary embodiment of the present invention.

Referring to FIG. **1**, a display device according to an exemplary embodiment of the present invention may include a display panel **100**, a scan drive unit **200**, a data drive unit **300**, an expansion detecting unit **400**, and a control unit **500**.

The display panel **100** may be a region on which an image is displayed, and scan lines, data lines, and pixels may be arranged therein. The display panel **100** may be disposed on a flexible substrate. The flexible substrate may be deformed by external pressure and be made of a material such as glass, metal, polyimide (PI), polycarbonate (PC), polyethylene terephthalate (PET), polyether sulfone (PES), polyethylene naphthalate (PEN), and fiber reinforced plastic (FRP). The flexible substrate may further include a coating for maintaining flexibility in addition to the above-described materials forming the flexible substrate. As the display panel **100** is disposed on the flexible substrate, the display panel **100** may be expanded by external force. The expansion of the display panel **100** will be described in more detail with reference to FIGS. **2** and **3** below.

The scan drive unit **200** may apply a signal to a scan line connected to the corresponding pixel among scan lines arranged on the display panel **100**, in response to receiving a scan drive control signal (SCS) from the control unit **500**. The scan drive unit **200** may be disposed in an external region of the display panel **100** and electrically connected to the display panel **100** by first signal lines. The scan drive unit **200** may be formed of a rigid material. Accordingly, when the display panel **100** is expanded by the external force, the scan drive unit **200** may expand. Meanwhile, the first signal lines for electrically connecting the scan drive unit **200** and the display panel **100** may be made of a flexible material.

The data drive unit **300** may apply a signal to a data line connected to the corresponding pixel among the data lines arranged on the display panel **100**, in response to receiving a data drive control signal (DCS) from the control unit **500**. The data drive unit **300** may be disposed in an external region of the display panel **100** and electrically connected to the display panel **100** by second signal lines. The data drive unit **300** may be made of a rigid material. Accordingly, when the display panel **100** is expanded by the external force, the data drive unit **300** may not expand. Meanwhile, the second

signal lines for electrically connecting the data drive unit **300** and the display panel **100** may be made of a flexible material.

The expansion detecting unit **400** is disposed around the display panel **100** to detect whether the display panel **100** is expanded and a degree of expansion when the display panel **100** is expanded by the external force.

The control unit **500** may receive an image data from the outside, and generate control signals (SCS, DCS) that control the operation of the scan drive unit **200** and the data drive unit **300**, to display the received image data on the display panel **100**. The scan drive control signal SCS and the data drive control signal DCS applied to the scan drive unit **200** and the data drive unit **300** may include a image compensation control signal that may reflect compensation information on a resolution of image or on scaling of the image, and a timing control signal that may control the application timing of the drive signal according to the expansion, depending on the degree of expansion of the display panel **100**.

FIG. **2** is a block diagram schematically illustrating a partial configuration before the expansion of the display device of FIG. **1**, and FIG. **3** is a block diagram schematically illustrating a partial configuration after the expansion of the display device of FIG. **1**.

Referring to FIG. **2**, the display panel **100** according to an exemplary embodiment of the present invention may include scan lines (not illustrated), data lines (Dn, Dm), and pixels (P**1**, P**2**) arranged in a region defined by the scan lines (not illustrated) and the data lines (Dn, Dm). In addition, an expansion detecting unit **400** may be disposed at the lower end of the display panel **100**. The expansion detecting unit **400** may detect whether the display panel **100** is expanded by an external force and a degree of the expansion. The display panel **100** may be connected to the scan drive unit **200** by first signal lines **250** and connected to the data drive unit **300** by second signal lines **350**. The scan drive unit **200** may include a first scan drive IC **210** and a second scan drive IC **220**, and the data drive unit **300** may include a first data drive IC **310** and a second data drive IC **320**.

The display panel **100** may include hidden data lines (Dn+1, Dm+1) arranged at different layers from the data lines (Dn, Dm) arranged on the flexible substrate. As illustrated in FIG. **2**, when the display panel **100** is not expanded, the hidden data lines (Dn+1, Dm+1) arranged on the different layers are hidden from the display panel **100**. However, when the display panel **100** is expanded as illustrated in FIG. **3**, the hidden data lines (Dn+1, Dm+1) may appear on the display panel **100** depending on the degree of expansion. Accordingly, the hidden data lines (Dn+1, Dm+1) may define hidden pixels (P**1**-**1**, P**2**-**1**), in addition to the pixels (P**1**, P**2**) defined by the scan lines (not illustrated) and the data lines (Dn, Dm) before the expansion, in accordance with the degree of expansion. Appearance of the hidden data lines (Dn+1, Dm+1) on the display panel **100** may depend on the degree of expansion of the display panel **100**.

As the display panel **100** may further include the hidden data lines (Dn+1, Dm+1) arranged on the different layers of the flexible substrate from the data lines (Dn, Dm), second hidden signal lines (not illustrated) may be arranged on the different layers from the second signal lines **350** that electrically connect the display panel **100**, the first data drive IC **310**, and the second data drive IC **320**. Thus, when the expansion of the display panel **100** is detected by the expansion detecting unit **400**, the second hidden signal lines that electrically connect the display panel **100**, the first data drive IC **310**, and the second data drive IC **320**, may appear depending on the degree of expansion of the display panel **100**.

The expansion detecting unit **400** may include a single resistance line, a signal input terminal Tx configured to apply a pulse signal and disposed at one end of the resistance line, and a signal reception terminal Rx configured to receive the pulse signal input through the signal input terminal Tx and disposed at the other end of the resistance line. When the display panel **100** is expanded, a line width of the resistance line of the expansion detecting unit **400** may become thinner. Accordingly, the expansion detecting unit **400** may determine that the display panel **100** is expanded when a reception time, a time of which a pulse signal input through the signal input terminal Tx is received at the signal reception terminal Rx, is delayed compared to the reception time before the expansion. The expansion detecting unit **400** will be described in more detail below with reference to FIGS. **4** to **6**.

FIG. **4** is a block diagram schematically illustrating a configuration of the expansion detecting unit of FIG. **1**. FIG. **5** is timing diagram illustrating a change in a signal level of the expansion detecting unit before the expansion of the display device of FIG. **1**. FIG. **6** is a timing diagram illustrating a change in a signal level of the expansion detecting unit after the expansion of the display device of FIG. **1**.

Referring to FIG. **4**, the expansion detecting unit **400** may include an expansion or non-expansion determining unit **410** and an expansion degree determining unit **420**.

The expansion or non-expansion determining unit **410** may determine whether the display panel **100** is expanded by comparing a reception time of signal to a predetermined reference signal. The reception time may be a time of which a pulse signal or a clock signal input through the signal input terminal Tx is received at the signal reception terminal Rx. More particularly, when a pulse signal is input through the signal input terminal Tx, and the reception time of receiving the pulse signal at the signal reception terminal Rx is delayed than the predetermined reference time, the expansion or non-expansion determining unit **410** may determine that the display panel **100** is expanded. When the reception time is not delayed than the predetermined reference time, the expansion or non-expansion determining unit **410** may determine that the display panel **100** is not expanded. More particularly, as illustrated in FIG. **5**, when the reception time of which the pulse signal input through the signal input terminal Tx is received at the signal reception terminal Rx is within a predetermined range of the reference time, the expansion or non-expansion determining unit **410** may determine that the display panel **100** is not expanded. Meanwhile, as illustrated in FIG. **6**, when the reception time is not within the predetermined range of the reference time, the expansion or non-expansion determining unit **410** may determine that the display panel **100** is expanded.

The expansion degree determining unit **420** may include an XOR calculation unit. The XOR calculation unit may receive input values from the signal input terminal Tx and the signal reception terminal Rx to calculate an XOR value T. The input value of the signal input terminal Tx may be an input time of the pulse signal to the signal input terminal Tx, and the input value of the signal reception terminal Rx may be a reception time of the pulse signal at the signal reception terminal Rx. When the display panel **100** is determined to be expanded, the expansion degree determining unit **420** may compare the calculated XOR value T with a predetermined reference set value. When the calculated XOR value T is

equal to or less than the predetermined reference set value, the expansion degree determining unit **420** may determine that the display panel **100** is expanded, but not to a degree that may render appearance of the hidden data lines (Dn+1, Dm+1), and correct an image accordingly. When the calculated XOR value T exceeds the predetermined reference set value, the expansion degree determining unit **420** may determine that the hidden data lines (Dn+1, Dm+1) appear while the display panel **100** is expanded, and correct the image accordingly.

According to an exemplary embodiment of the present invention, the reference set value may be determined by subdividing an output width of the XOR illustrated in FIGS. **5** and **6** into a small number of clocks, according to a setting based on the output width of the XOR. For example, when the number of the small clocks exceeds **100**, the pixels are determined to be separated, and when the number of counts does not exceed **100**, the pixels are determined not to be separated. Although it is not illustrated, the expansion or non-expansion determining unit **420** may include a look-up table (LUT) to determine a more accurate degree of expansion. Further, although the expansion degree determining unit **420** is described as being included in the expansion detecting unit **400**, the expansion degree determining unit **420** may alternatively be included in the control unit **500**.

FIG. **7** is a flowchart illustrating a method of controlling the display device of FIG. **1**.

Referring to FIG. **7**, in step **710**, it is determined whether the display panel **100** is expanded by an external force. Whether the display panel **100** is expanded is determined by comparing a reception time of which a pulse signal input through the signal input terminal Tx is received at the signal reception terminal Rx to a predetermined reference time.

In step **720**, when the display panel **100** is determined to be expanded, the values of the signal input terminal Tx and the signal reception terminal of Rx are input to calculate XOR T, and a degree of expansion may be determined by comparing the calculated XOR value T to a predetermined reference set value. The input value of the signal input terminal Tx may be an input time of the pulse signal to the signal input terminal Tx, and the input value of the signal reception terminal Rx may be a reception time of the pulse signal at the signal reception terminal Rx. If the calculated XOR value T is smaller than the predetermined reference set value, it is determined that the display panel **100** is expanded, but not to the degree rendering the hidden data lines (Dn+1, Dm+1) to appear in the display panel **100**. Accordingly, in step **730**, if the calculated XOR value T is smaller than the predetermined reference set value, only the scaling operation may be implemented to an image to be displayed on the display panel **100**.

If the calculated XOR value T is greater than a predetermined reference value, it is determined that the hidden data lines (Dn+1, Dm+1) in the display panel **100** appear while the display panel **100** is expanded, so as to increase the number of pixels. Accordingly, in step **740**, if the calculated XOR value T is greater than a predetermined reference set value, the image to be displayed on the display panel **100** may be corrected by increasing a resolution of the image to two to three times higher.

As described above, an image may be corrected by modifying a resolution of the image by comparing the predetermined reference set value, or by correcting the scaling.

FIGS. **8** and **9** illustrate a method of correcting an image when the expansion is detected by the expansion detecting unit **400**, according to an exemplary embodiment of the present invention.

FIG. **8** is a plan view schematically illustrating a signal applied to the display panel from the data drive unit before the display device is expanded, and FIG. **9** is a plan view schematically illustrating a signal is applied to the display panel from the data drive unit after the display device is expanded.

As illustrated in FIG. **8**, in the display device according to an exemplary embodiment of the present invention, when an expansion detecting unit **400** determines that the display panel **100** is not expanded, a control unit **500** may control the first data drive IC **310** and the second data drive IC **320** to apply a data signal to each pixels at the same timing.

Referring to FIG. **9**, in the display device according to the present exemplary embodiment, when the expansion detecting unit **400** determines that the display panel **100** is expanded, a delayed time is calculated by comparing a difference between an input time of the pulse signal at the signal input terminal Tx of the expansion detecting unit **400** and the reception time of the pulse signal at the signal reception terminal Rx, to a reference value. The timing of the data signal applied to each pixel from the first data drive IC **310** and the second data drive IC **320** may be controlled depending on the calculated delayed time. More particularly, the data signal may be applied to each pixel at different timings in accordance to the delayed time. When the display panel **100** is expanded in a vertical direction, the control unit **500** may control the signal application timing of the first scan drive IC **210** and the second scan drive IC **220** according to the delayed time.

Accordingly, the display device according to an exemplary embodiment of the present invention may correct an image of the display panel **100** or control the application timing of the signal depending on the degree of expansion, by detecting the expansion of the display panel **100** from an external force and simultaneously determining the degree of expansion. Thus, it may be possible to prevent deterioration of the display quality when the display panel **100** is expanded by the external force.

FIG. **10** is a block diagram schematically illustrating a display device according to an exemplary embodiment of the present invention.

The display device of FIG. **10** has the same configuration as the display device **100** of FIG. **1**, except for the configuration of the expansion detecting unit **400**. Referring back to FIG. **1**, the display device of FIG. **1** includes the expansion detection unit **400** disposed at the lower end of the display panel **100** to detect a horizontal expansion. The display device of FIG. **10** includes a first expansion detecting unit **401** and a second expansion detecting unit **402** disposed at a lower end portion and a side surface portion, to detect horizontal and vertical expansions. More particularly, the first expansion detecting unit **401** may detect the horizontal expansion, and the second expansion detecting unit **402** may detect the vertical expansion. Operations and elements of the first and second expansion detecting units **401** and **402** are substantially the same as the expansion detecting unit **400** illustrated with reference to FIGS. **4** to **6**, and therefore, repeated description thereof will be omitted.

FIG. **11** is a flowchart illustrating a control method of the display device of FIG. **10**.

Referring to FIG. **11**, in step **1110**, it is determined whether the display panel **100** is expanded by an external force. Whether the display panel **100** is expanded or not may

be determined by performing an XOR calculation on an input time of a pulse signal at the signal input terminal Tx and a reception time of the pulse signal at the signal reception terminal Rx, and if the calculated XOR value T is within a range of a reference value, the display panel **100** is determined not to be expanded, and when the calculated XOR value T exceeds the range of the reference value, the display panel **100** is determined to be expanded. When the display panel **100** is determined not to be expanded, an image signal may be output without correction.

When the display panel **100** is determined to be expanded, in step **1120**, it is determined whether the first expansion detecting unit **401** is expanded. When the first expansion detecting unit **401** is determined to be expanded, in step **1130**, the operations of the first data drive IC **310** and the second data drive IC **320** may be controlled to output the data signal to each pixel at different timing in accordance to a delayed time. The delayed time may be calculated by comparing a difference between the input time of the pulse signal at the signal input terminal Tx and the reception time of the pulse signal at the signal reception terminal Rx, to a second reference value.

In step **1140**, when the first expansion detecting unit **401** determines that the display panel **100** is not expanded, it is determined whether the second expansion detecting unit **402** is expanded. When the second expansion detecting unit **402** determines that the display panel **100** is expanded, in step **1150**, the operations of the first scan drive IC **210** and the second scan drive IC **220** may be controlled to output the scan signal to each pixel at different timing in accordance to the delayed time.

In step **1160**, when the second expansion detecting unit **402** determines that the display panel **100** is not expanded, the first and second expansion detecting units **401** and **402** may determine that the display panel **100** is expanded both vertically and horizontally, and in step **1170**, the operations of the first data drive IC **310**, the second data drive IC **320**, the first scan drive IC **210**, and the second scan drive IC **220** may be controlled to output the data signal and the scan signal each pixel at different times according to the delayed time.

While FIG. **11** illustrates controlling the timing of the drive signal according to the detection of the expansion by the first expansion detecting unit **401** and the second expansion detecting unit **402**, according to an exemplary embodiment of the present invention, the image signal may be corrected according to the delayed time, as illustrated with reference to FIG. **7**.

Although certain exemplary embodiments and implementations have been described herein, other embodiments and modifications will be apparent from this description. Accordingly, the inventive concept is not limited to such exemplary embodiments, but rather to the broader scope of the presented claims and various obvious modifications and equivalent arrangements.

What is claimed is:

1. A display device, comprising:

a display panel comprising scan lines, data lines, and first pixels disposed thereon;

an expansion detecting unit comprising a resistance line configured to measure a time delay to determine expansion of the display panel;

a control unit configured to generate a control signal to correct an image signal depending on a degree of the expansion when the display panel is determined to be expanded;

a scan driver connected to the scan lines and configured to apply the control signal to the scan lines connected to the corresponding pixels according to the control signal from the control unit; and

a data driver connected to the data lines and configured to apply the control signal to the data lines connected to the corresponding pixels according to the control signal from the control unit.

2. The display device of claim **1**, wherein the display panel is disposed on a flexible substrate.

3. The display device of claim **1**, wherein the expansion detecting unit comprises:

an expansion or non-expansion determining unit configured to determine the expansion of the display panel; and

an expansion degree determining unit configured to determine the degree of expansion of the display panel when the display unit is determined to be expanded.

4. The display device of claim **3**, wherein the expansion or non-expansion determining unit comprises:

the resistance line;

a signal input terminal disposed at one end of the resistance line to receive a pulse signal; and

a signal reception terminal disposed at the other end of the resistance line to output the input pulse signal.

5. The display device of claim **4**, wherein:

the expansion or non-expansion determining unit is configured to determine that the display panel is not expanded when a reception time is equal to or smaller than a first reference value, the reception time comprising a time period during which the pulse signal input to the signal input terminal is received at the signal reception terminal; and

the expansion or non-expansion determining unit is configured to determine that the display panel is expanded when the reception time is greater than the first reference value.

6. The display device of claim **4**, wherein the expansion degree determining unit comprises an XOR calculation unit configured to generate a calculated XOR value from input values of the signal input terminal and the signal output terminal.

7. The display device of claim **6**, wherein the control unit is configured to determine the degree of the expansion of the display panel by comparing the calculated XOR value to a reference set value.

8. The display device of claim **7**, wherein:

the control signal comprises a first control signal and a second control signal;

the control unit is configured to generate the first control signal when the calculated XOR value is smaller than the reference set value, the first control signal configured to correct scaling of the image signal to be displayed on the display panel; and

the control unit is configured to generate the second control signal when the calculated XOR value is greater than the reference set value, the second control signal configured to increase a resolution of the image signal to be displayed on the display panel.

9. The display device of claim **1**, wherein:

the display panel further comprises second scan lines and second data lines disposed on a different layer from the scan lines and the data lines so that the second scan lines and the second data lines are hidden when the display panel is not expanded; and

the second scan lines and the second data lines are configured to appear on the display panel depending on

the degree of the expansion of the display panel to define second pixels different from the first pixels.

10. The display device of claim **9**, wherein the control signal is configured to increase a resolution of the image signal of the display panel when the display is determined to be expanded and the second scan lines and the second data lines are determined to appear on the display panel.

11. A display device, comprising:

a display panel comprising scan lines, data lines, and pixels disposed on the display panel in a region defined by the scan lines and the data lines;

an expansion detecting unit comprising a resistance line configured to measure a time delay to determine expansion of the display panel; and

a control unit configured to generate a control signal and control the operation of a scan drive unit and a data drive unit depending on a degree of the expansion of the display panel when the display panel is determined to be expanded,

wherein:

the scan drive unit is connected to the scan lines and configured to apply the control signal to the scan lines connected to the corresponding pixels depending on the control signal input from the control unit;

the data drive unit is connected to the data lines and configured to apply the control signal to the data lines connected to the corresponding pixels depending on the control signal input from the control unit; and

the scan drive unit and the data drive unit are configured to control a timing of a scan signal or a data signal applied to the display panel depending on a degree of the expansion of the display panel.

12. The display device of claim **11**, wherein the scan drive unit and the data drive unit are configured to delay a timing of applying the scan signal and the data signal, respectively, to the display panel according to the degree of the expansion of the display panel.

13. The display device of claim **11**, wherein the expansion detecting unit comprises:

an expansion or non-expansion determining unit configured to determine expansion of the display panel; and

an expansion degree determining unit configured to determine the degree of the expansion of the display panel when the display panel is determined to be expanded.

14. The display device of claim **13**, wherein the expansion or non-expansion determining unit comprises:

the resistance line;

a signal input terminal disposed at one end of the resistance line to receive a pulse signal; and

a signal reception terminal disposed at the other end of the resistance line to output the input pulse signal.

15. The display device of claim **14**, wherein:

the expansion or non-expansion determining unit is configured to determine that the display panel is not expanded when a reception time is equal to or smaller than a first reference value, the reception time comprising a time the pulse signal input to the signal input terminal is received at the signal reception terminal; and

the expansion or non-expansion determining unit is configured to determine that the display panel is not expanded when the reception time is greater than the first reference value.

16. The display device of claim **15**, wherein the expansion degree determining unit comprises an XOR calculation unit configured to calculate the reception time of the pulse signal from the signal input terminal to the signal reception terminal and generate a calculated XOR value.

17. The display device of claim **16**, wherein the control unit is configured to determine a delayed time based on the calculated XOR value and control a timing of applying the scan signal and the data signal to the display panel according to the delayed time.

18. A method of driving a display device, the method comprising:

determining whether the display panel is expanded by an external force such that a distance between adjacent pixels in the display panel is increased;

comparing a reference set value with a calculated value to determine a degree of expansion in response to determining that the display panel is expanded;

scaling an image signal when the reference set value is greater than the calculated value; and

increasing a resolution of the image signal when the reference set value is smaller than the calculated value.

19. The method of claim **18**, wherein determining whether the display panel is expanded by an external force comprises:

comparing an input time of a pulse signal applied to a first end of a resistance line and a reception time of the pulse signal from a second end of the resistance line to a reference time; and

determining that the display panel is expanded when a time difference between the input time and the reception time is greater than the reference time.

20. The display device of claim **19**, wherein the calculated value comprises an XOR calculated value of the input time of the pulse signal and the reception time of the pulse signal.

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